SECTION II.—GENERAL METEOROLOGY

A REMARKABLE FALL OF HAIL IN MARYLAND.

By OLIVER L. FASSIG, Professor of Meteorology.

[Dated: Weather Bureau, Baltimore, Md., Sept. 4, 1915.]

First accounts of hailstones of unusual size are apt to be exaggerated. When the daily papers published reports of a severe local storm which passed over central Maryland in the afternoon of June 22, 1915, accompanied by hail as large as a baseball or an orange, the writer was inclined to make further investigation before accepting the statement literally, although some of the accounts were accompanied by measurements and detailed descriptions. Brief inquiry among the residents of Annapolis, where the largest stones appear to have fallen, showed however, not only unusual accuracy in the first reports, but revealed the remarkable fact that the first newspaper reports actually failed to give a sufficiently vivid account of this phenomenal storm.

Path of storm.—The fall of hail was apparently confined to central and northern Maryland and to Delaware, although thunderstorms prevailed over a much greater area, extending into neighboring States on the north.

Reports indicate that the hail began about 1:30 p. m. in the western portion of Carroll County, Md., and that the storm moved southeastward across Howard and Anne Arundel Counties, crossed Chesapeake Bay into Talbot, Dorchester, and Wicomico Counties. It probably passed over the Atlantic, through Worcester County, at about 5 p. m. The hail was particularly destructive to crops and exposed windows within the narrow belt, probably less than 5 miles wide, extending from Union Bridge along the southwest border of Carroll County, through Sykesville, Woodstock, Ellicott City, Annapolis, Claiborne, and Oxford. (See fig. 1.)

Judging from the size of the hailstones alone, the storm seems to have attained its maximum intensity between 2:30 p. m. and 3 p. m., as it passed over the city of Annapolis, although the stones were almost as large, apparently, near Woodstock and Ellicott City, in Howard County, and at Claiborne, across the Bay from Annapolis, in Talbot County.

Other storms of the day.—Hail, although not of unusual size, was reported from a number of localities to the north of the path followed by the storm described above, namely, Darlington in Harford County, and Sudlersville in Queen Anne's County, Md., and Millsboro in Sussex County, Del. These towns are located along a line parallel with the path described and the storms probably belong to another series, as they occured about an hour later in the afternoon.

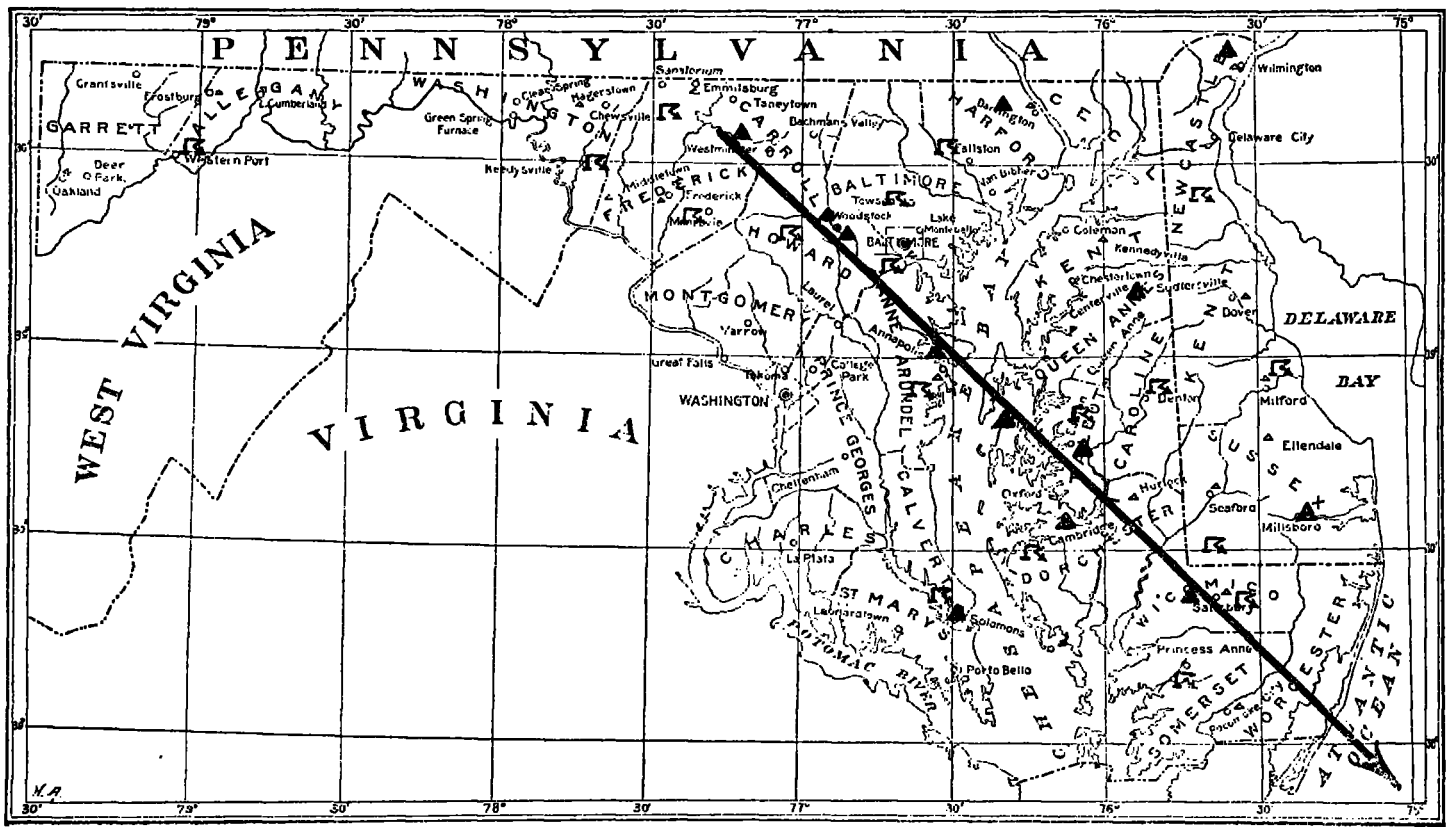

FIG. 1.—The path of the hailstorm of June 22, 1915, across Maryland and Delaware.
▲, localities reporting hail; ⟦, localities reporting thunderstorms.

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FIG. 2.—Hailstones gathered at the experiment station of the U. S. Naval Academy, Annapolis, Md., June 22, 1915. (Bottom of tray containing hailstones is 10½ inches long.) Average dimensions of 10 selected stones were 3½ by 3 inches; maximum diameter of the largest measured stone was 3$\frac{15}{16}$ inches.
Wired-glass fragments, $\frac{5}{16}$ inch thick, from the shattered skylights of the Academy buildings.

Size of hailstones.—The hailstones were of a size never before seen in this vicinity. The large ones were generally referred to as being the size of a baseball or an orange. Numerous measurements of individual hailstones were reported. Among the most reliable known to the writer are those made by two officials of the United States Naval Academy. Ten or twelve stones, accurately measured, gave an average diameter of $3\frac{1}{2} \times 3$ inches, with a maximum major diameter of $3\frac{15}{16}$ inches. In another series of measurements the largest stones exceeded 4 inches in diameter. These measurements are equivalent to a circumference ranging from 10 to 12 inches. Reports from observers in other localities are in harmony with these figures. A hailstone picked up at Ellicott City measured $9\frac{3}{8}$ inches in circumference.

Stones the size of a baseball (i. e., 9 in. or 228.6 mm. in circumference) were not at all uncommon along the path of the storm from Woodstock to Claiborne. All accounts of observers at Annapolis agree that the ground there was never covered with hail, and that the larger stones were probably never more numerous than 8 or 10 to the square yard (0·84 sq. m.).

Weight of hailstones.—Statistics as to the weight of individual stones are less numerous. Information available is to the effect that "they averaged from 3 to 4 ounces"; that "they ran about 5 to the pound"; that "3 of them weighed a pound"; and "that some weighed 6 to 7 ounces, while stones 4 to the pound were not uncommon". The circumference of a league baseball measures 9 inches, and its weight is 5 ounces; hence the comparison commonly made holds both as to weight and size.

Structure and shape.—The structure of the hail was similar to that usually met with, namely, a nucleus of snow or opaque ice, with concentric shells of alternately transparent and opaque ice. In some of the larger stones from 20 to 25 such layers were counted.

There was also the usual diversity in shape. Some stones were nearly spherical; some spheroidal, prolate, and oblate; some disk-shaped; some top-shaped. Some resembled a small cymling,[1] some were with prongs or knobs, and some without.

Damage done.—It is rather remarkable that such a shower of stones lasting from 15 to 20 minutes and passing over a city with a population of approximately 10,000 should have caused so little personal injury. The writer heard of only two men who received scalp wounds of sufficient severity to require hospital treatment. Injuries to horses were numerous. According to reports, one horse had the good judgment to take refuge in a near-by grocery store.

The force of the impact of hailstones may be gaged quite accurately from the destruction wrought in the glass roofs of the Naval Academy buildings. About half of the panes of glass in the skylight of the gymnasium, between 400 and 500 in number, had to be replaced; the glass was fully half an inch (1 cm.) in thickness. The skylights in the roof of the main building of the experiment station, across the Severn, contained glass $\frac{5}{16}$ inch thick with embedded wire netting. The accompanying photograph, figure 2, shows a tray filled with some of the larger hailstones gathered near the experiment station. To the right and left of the tray are shown fragments of the wire-glass shattered by the hail. The irregular and spiked outline of some of the stones is clearly indicated in the picture.

The following interesting accounts of the storm and of the remarkable hailstones, are taken from letters received from Rev. J. F. Dawson, S. J., of Woodstock College, a cooperative observer of the Weather Bureau, and from Mr. F. S. Bullard, of Annapolis, who is connected with the experiment station of the Naval Academy:

The hailstorm of June 22, 1915, seemed to develop a few miles north or northwest of Sykesville; some place between Sykesville and Westminster. It was very violent near Eldersburg, on the Liberty Road, and on two farms in that neighborhood practically the whole crop was destroyed. The stones in that region were smaller than at Woodstock and cut the corn to pieces. With us the damage was done by breaking off the smaller stalks. The storm moved toward the southeast, the center crossing the Baltimore & Ohio Railroad near Gorsuch station, about 3 miles east of Sykesville. The center passed a little to the west and south of us, and along the line of its passage the stones seemed to be smaller than at the college. I am inclined to think that it went a little south of Ellicott City and north of Laurel, but am not sure.

With us the stones were not spherical, but were ellipsoids, nearly all prolate, but quite a number oblate. The larger were composed of fully 20 or 25 layers, alternately clear ice and white snow ice. Generally the nucleus was composed of white softer ice. I never saw any that equaled them in size. The measurements I sent you ($2\frac{1}{2}$ inches) were not those of the very largest, but were taken from stones that were numerous.—*J. F. Dawson, S. J., Woodstock College.*

The hailstone picture I sent you was taken by Mrs. Bullard. She weighed several of them and they ran about five to the pound.

I was at the experiment station [of the Naval Academy]. The hailstones were much larger, and there were more of them, on that side of the [Severn] river. I measured several that were over 4 inches in diameter. A very interesting feature was their peculiar shape, being covered all over with nobs or horns; others were pear-shaped, while still others were wedge-shaped, with rounded top. Some of the larger ones had snow inside.

A few of the larger stones crashed through our skylight like a cannon ball and fell to the floor unbroken. The smaller ones just shattered the glass, which was $\frac{5}{16}$ inch in [thickness] and reinforced with wire.

The storm lasted from 15 to 20 minutes. The spectacle on the water was very weird and interesting. The splashes of the falling hailstones rose 3 or 4 feet, and there were so many of them that it looked as if the river rose right up. The hail was so thick that you could not see across the river.

I inclose a small piece of the broken skylight. The damage at the experiment station was about $3,500.—*F. S. Bullard, U. S. Naval Academy Experiment Station, Annapolis, Md.*

An interesting but unconfirmed account stated that small pebbles were found at the center of some of the larger hail gathered at Annapolis. The young man who related the story offered to produce the pebbles, but has not yet done so.[2] The observer was doubtless sincere in his belief that the pebbles were in the hail as it fell, but as the hailstones in question were apparently gathered in the street, it is probable that the pebbles were picked up when the hail struck the ground, and that they were too deeply embedded to be noticed until the hailstones melted. Until a more accurate account is at hand of the circumstances under which the hail was gathered and melted, the story must be classed with the numerous rumors which may be labeled "important—if true."

Previous accounts.—The literature of hailstorms contains references to stones of larger size than those gathered at Annapolis on June 22, 1915, but such instances are rare and, so far as the writer is aware, confined to foreign lands. Dr. von Hann, in the latest edition of his "Handbuch der Meteorologie," cites occurrences of hailstones measuring from 4 to 6 inches in diameter and weighing over a pound. We frequently read about hail of much greater size, but such reports, upon investigation, generally prove to be exaggerations; sometimes they refer

[1] *Cymling*, the scalloped "pattypan" or summer squash (*Cucurbita pepo*, var. *condensa*), also spelled "simlin."
The Century Dictionary says: "Simnel. . . . 2. A variety of squash having a round flattish head with a wavy or scalloped edge and so resembling the cake [or simnel]: now called simlin."

[2] Since writing this the author states he has received some of these pebbles.

to a cluster of individual stones which froze together while falling or after reaching the ground.

India seems to be a land of frequent occurrence of hail of unusual size. Eliot, in a study of Indian hailstorms, tabulated measurements of the hailstones of 600 storms, and found that in 27 per cent of the measurements the stones were smaller than peas; in 51 per cent they were larger than peas, but smaller than a lemon; in 22 per cent they were larger than a lemon. Another investigator, Bruist, found the *mean maximum circumference* of Indian hailstones to be from 4 to 6 inches, with a weight varying from 2.2 to 4.4 ounces. The largest were 10 to 13 inches in circumference, weighing from 0.62 to 1.24 pounds.

In the light of recent knowledge of the temperature conditions existing in the upper atmosphere and of the general weather conditions which accompany severe local disturbances, such as tornadoes, thunderstorms, and hailstorms, it is not a difficult matter to account for the production of hail during the warm months of the year. But the manner in which masses of ice are sustained in the atmosphere long enough to acquire a weight of many ounces is still something of a mystery. However, we

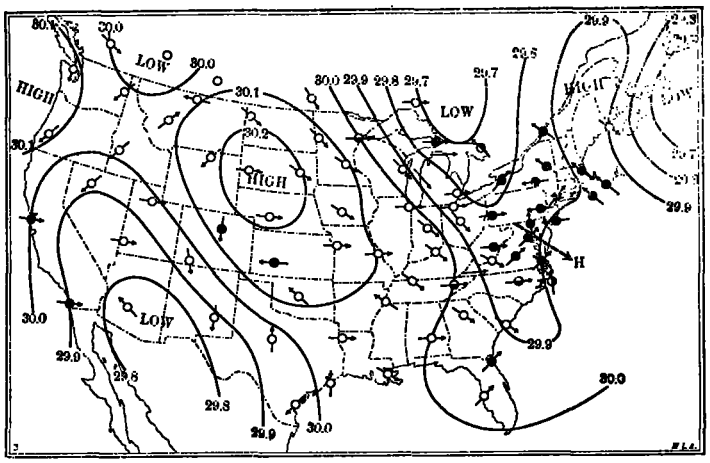

FIG. 3.—General weather conditions at 8 a. m., June 22, 1915. The hailstorm occurred six hours later along the dotted line, *H*, across Maryland.

know that hailstorms exhibit evidences of rapid and powerful rising currents within the central cloud masses; that there is generally an incessant play of lightning between the clouds, and that these clouds are built up to great heights, retaining the liquid character of their particles in a subcooled condition with temperatures far below freezing. Volta long ago accounted for the onion-like structure of hailstones by assuming that the hail nucleus, once formed, is kept in a state of oscillation between oppositely electrified clouds until the constant accretion of layers of ice so increases the weight that the hailstone can be no longer sustained by the movements of the atmosphere, and falls to the ground. Variations in the electrical potential of cloud particles are known to cause the particles to coalesce. Ferrel suggested that the strong ascensional currents within a hailstorm carried the hailstones to great heights, receiving constant accretions on their way, and that it is probable that the hail, falling out of the strong ascensional currents or being thrown out, may be repeatedly carried up to altitudes where the temperature is below freezing and thus grow to great size before falling to the ground.

General weather conditions.—The 8 a. m. weather map of June 22, 1915, showed a general condition very favorable for the formation of severe local storms. (See fig. 3). A well-developed and extensive area of high pressure was moving rapidly eastward across the Central States. There was a narrow ridge of relatively high pressure over the New England States and extending southward over the Atlantic Ocean. The Lower Lake Region, the Middle and the South Atlantic States, were in a trough of low pressure, with a sharply defined "squall line" separating the southerly and easterly winds and overcast skies from the strong westerly winds and clear skies. The V-shaped depression was moving from southwest to northeast across the Middle Atlantic States; the local thunderstorms and hailstorms which formed along the advancing front of the area of high pressure, or along the squall line, moved southeastward across Maryland and Delaware at the rate of approximately 50 miles per hour.

At Baltimore the barometer fell steadily from midnight of June 21 to nearly 5 p. m. of the 22d, when it rose abruptly 0.05 inch. This jump was accompanied by a change in the direction of the wind from southerly to northerly, marking the passing of the "squall line." Earlier on the 22d, between 1:30 p. m. and 2 p. m., a thunderstorm was observed west of the city moving from northwest to southeast. Undoubtedly this was the storm which produced the heavy fall of hail at intervals along the path from Carroll County to the Atlantic Ocean.

INFLUENCE OF A FOREST ON THE TEMPERATURE OF AN AIR CURRENT.[1]

L'abbé MICHEL LALIN.

[Dated: Vievigne (Côte-d'Or), Mar. 26, 1913.]

* * * My observations are here confined to the single problem of what influence a wooded region may exert on the temperature of a current of air.

The forest of Four (Bois du Four) between Spoy and Vievigne in the Côte-d'Or has a width of about 800 meters. Two thermometers, graduated to one-tenth degree [centigrade] were set up on the eastern and western margins at a distance of about 30 meters from the wood. At each observation their readings were checked against the reading of a whirled thermometer.

Between May 15 and September 30 I made 70 observations at various hours but most often in the forenoon. The results are as follows:

EAST wind, 17 times: On the E. margin the thermometer always showed readings 0.3° to 0.8°C. *higher* than those on the W. margin.

WEST wind, 26 times: The thermometer on the E. or downstream from the wood showed readings 0.3° to 0.75°C. lower than those on the W. margin.

RAIN, 8 times: Wind was W. or SW., but the temperature was the same on either margin of the wood.[2]

CALMS or the wind did not blow across the wood from one station to the other, 19 times: The thermometers were in accord.

I conclude that the current of air has cooled in passing through this thin tree-curtain.

On examining the figures it seems to me that one is led to conclude that this modification in temperature is quite independent of the initial temperature of the air and depends solely on the velocity of the wind. The lighter the wind, the greater is the difference. The maximum difference of 0.8°C. corresponded with a wind of velocity 3 on

[1] Assoc. Franc. pour l'Av. des. sci., Compte rendu de la 42me sess. Tunis, 1913: Notes et Mémoires. Paris. 1914. pp. 242-243.

[2] This is readily explained as the result of the lower calorific capacity of water.—*Author.*